Talc: A Possible Occupational and Environmental Carcinogen

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Talc is mineralogically closely related to three of the five major asbestos group minerals, specifically, the serpentine Chrysotile, as well as the first two of the amphiboles Anthophyllite, Tremolite, Amosite and Crocidolite. In certain toxicological aspects, talc and asbestos are also closely related: They are silicates which produce fibrosis of the lung and other tissues. Talcs and the asbestos minerals cited are hydrous magnesium silicates difficult to differentiate—except with special techniques such as electron microscopy with selected area diffraction—and which form in the same as well as similar geological processes. Consequently, many talc deposits contain asbestos minerals, so that in industrial and commercial use, such talcs always contain varying amounts of asbestos fibers. Because of this asbestos contamination of talcs, we reviewed data on: (1) The composition of talc and related asbestos minerals; (2) The toxic effects of both substances; (3) The general environmental exposures to talc; and (4) Its common uses, including those involving ingestion of talc-containing foods and drugs. Additionally, (5) Mineral residues from talc-coated rice washings were analyzed for asbestos. Then we re-evaluated such data, together with new findings on the asbestos contamination of talc-coated polished white rice. As a result, we present some new conclusions about related possible health risks arising from occupational and environmental exposures to asbestos contaminated talcs.

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Definitions and Composition of Talc

Pure talc and the three related asbestos group minerals are hydrous magnesium silicates whose theoretical chemical formulae are:

True Talc	$Mg_6\ Si_8\ O_{20}\ (OH)_4$
Anthophyllite Asbestos	$Mg_7\ Si_8\ O_{22}\ (OH)_2$
Chrysotile Asbestos	$Mg_6\ Si_4\ O_{10}\ (OH)_8$
Tremolite Asbestos	$Ca_2\ Mg_5\ Si_8\ O_{22}\ (OH)_2$

Mineralogically, there are two forms of talc: Nonasbestiform, also called platy or nonfibrous, and Fibrous, also called tremolitic. As used commercially, however, the term "talc" connotes certain desired physical properties rather than a mineral species: It includes all gradations, from the pure mineral to impure massive talcose rocks, such as soapstone. In fact, some commercial talc deposits can contain a very small talc content with varying amounts of many accessory minerals, such as asbestos, quartz, and other "impurities." In the United States, for example, the Saint Lawrence County, New York State commercial talc deposits contain 30% or less of mineralogically pure talc. The remainder consists partly of: (1) Serpentine, the host mineral of chrysotile, antigorite and lizardite; (2) Tremolite; and Anthophyllite, which can convert naturally to talc. Although mineralogical "impurities," the asbestos minerals are considered in many cases as an integral part of such commercial talc, whereas other mineralogical impurities, such as hematite and pyrite, are commercially unacceptable.[1] An example is that talcs

Table 1. — Observed and Expected Deaths, By Cause Among 632 Asbestos Insulation Workers Observed Prospectively 1 January 1943 — 30 June 1971*

Cause of Death	Deaths: Number, Observed	Deaths: Number, Expected	Ratio Observed to Expected	Percent Observed
Total, All Causes	418	282.1	1.5	100.0
Total Cancer (All Sites)	187	51.6	3.6	44.7
Cancer of the Lung, Pleura Trachea, Bronchus	92	11.1	8.3	22.0
Lung Cancer	85	†	7.7	20.3
Pleural Mesothelioma	7	‡	—	1.7
Peritoneal Mesothelioma	19	‡	—	4.5
Cancer of Stomach, Colon, Rectum	41	12.4	3.3	9.8
Cancer of All Other Sites	35	28.1	1.2	8.4
Asbestosis	32	‡	—	7.7
All Other Causes	199	230.5	0.9	47.6

* Source: Selikoff et al.[6,7]

† US data not available, but figure should be only slightly less than 11.1.

‡ US data not available, but these are rare causes of death in the general population.

Table 2. — Deaths and Expected Mortality from Cancer of the Lung and Pleura and Gastrointestinal Tract and Peritoneum Related to Age in Talc Workers*

Age Group	Total Deaths	Deaths From Malignant Causes: Lung and Pleura	Deaths From Malignant Causes: GI‡ and Peritoneum	Proportional Mortality†: Lung and Pleura: Observed	Proportional Mortality†: Lung and Pleura: Theoretical	Proportional Mortality†: GI‡ and Peritoneum: Observed	Proportional Mortality†: GI‡ and Peritoneum: Theoretical
Total	91	10	7	11	3.2	7.7	5.3§
Less than 40	2	0	0	0		0	
40 - 59	38	2	2	5.3	5.5§	5.3	5.5§
60 - 79	47	8	4	17	3.9	8.5	6.9§
80 and Over	4	0	1	0		25	4.3¶

* After Kleinfeld et al.[9]

† Number of deaths in a group divided by total deaths in same group x 100.

‡ Gastrointestinal tract.

§ Difference not statistically significant.

‖ Difference statistically significant ($p = < 0.01$).

¶ Statistical analysis not done due to small number in group.

for milling are often chosen preferentially on the basis of how much "impurity" is present, apparently because talc with larger, purer grains is more difficult to mill. Also of note is that the most recent revision of the *US Pharmacopeia*[2] does not specifically exclude asbestos as an impurity in its definition of pharmaceutical grade talc. The World Health Organization[3] in its 1971 reevaluation of food additives noted that asbestos is a contaminant in some talcs. All of these are factors which make it imperative to ascertain the mineralogical type and purity of talcs in assessing their potential health effects.

Toxic Effects

Asbestos. — Different forms of asbestos appear to have different biological effects. These differences are still too incompletely understood and complex to be discussed here, except as mentioned briefly below. Nevertheless, it can be stated that carcinogenicity is the most serious toxic effect of the various asbestos group minerals. In the last few decades in particular, these substances, especially some types of crocidolite, have been occupationally associated with greatly excessive incidence of pleural and peritoneal mesotheliomas, previously extremely infrequent cancers in humans.[4] Moreover, a number of researchers have experimentally induced pleural mesotheliomas after intrapleural injection of various forms of asbestos and demonstrated the neoplastic nature of those tumors.[5] As shown in Table 1, Selikoff et al[6] recently reported that among a cohort of 632 asbestos insulation workers, of the 418 deaths observed from January 1, 1943, to June 30, 1971, 20% were due to bronchogenic carcinoma, 10% to cancer of the stomach, colon, and rectum, and 6% to pleural and peritoneal mesothelioma. The asbestos forms used in the past by these workers were mostly chrysotile and amosite, with possibly small amounts of crocidolite.

As a group, the same asbestos insulation workers show about eight times an excess mortality from bronchogenic carcinoma. Moreover, asbestos insulation workers who smoke have a 92-fold risk of dying from bronchogenic carcinoma, as compared with men who neither smoke nor work with asbestos.[7] Thus, this type of occupational asbestos inhalation exposure points to another effect of asbestos, that of a cocarcinogen.

The asbestos group minerals have the added toxic effect of fibrogenicity which results in: Asbestosis, the well-known occupational lung fibrosis due to chronic inhalation overexposure; Pleural plaques and calcifications; as well as the less well-known asbestos corns or "warts" of the skin among workers handling such materials.

As mentioned, toxicological effects of different forms of asbestos appear to be different. For example, as compared with chrysotile, exposure to the amphiboles is generally more likely to produce asbestosis and bronchogenic carcinoma. Also, inhalation of crocidolite—especially of some types with shorter, finer fibers as measured by electron microscopy—appears to produce more mesotheliomas than other amphiboles and chrysotile. This subject was reviewed recently and succinctly by Wagner.[8]

In addition, inhaled asbestos particles retained in lung tissues can be covered with a proteinaceous-iron coating which produces a type of ferruginous body commonly termed "asbestos body."

Talc. — As shown in Table 2, Kleinfeld et al[9] demonstrated that talc miners and millers in Northern New York State have 3.4 times an excess mortality from lung and pleural carcinomas. Such excess was shown to be statistically significant and appeared 20 years later than among asbestos insulation workers. The New York investigators ascribed this difference, in part, to talc being less carcinogenic than asbestos, without considering the fact that talc deposits in the northern part of that state contain much asbestos, as we noted above. No significant difference was found between the observed and expected mortality from carcinoma of the gastrointestinal tract and peritoneum among these talc workers.[9]

A well-known effect of talcs, especially the fibrous variety, is talcosis, another of the many occupational lung fibroses. Other toxic effects are the production of granulomas in wounds and scars, and intense mesothelial irritation, with fibrosis and adhesion in the pleural and peritoneal cavities. These occurred often in the past, due to the operated tissues being contaminated with the talc used as dusting powder for and shed from surgical gloves—a use no longer recommended.[10] Likely for similar reasons, the Kaiser Foundation Hospital in Los Angeles discontinued the use of "talcum" powders for any inpatient use. A bizarre, new and serious talc effect is that of pulmonary intravascular granulomas with vascular thrombosis and sclerosis leading to pulmonary hypertension, due to intravenous injection of talc-containing oral tablets and talc-adulterated substances in drug misuse.[11]

Inhaled fibrous talc particles can also be changed by cells in the lung into another type of ferruginous body which some call "talc bodies."

Hygienic Work Standards

Asbestos. — For 1972, the Committee on Threshold Limit Values for Airborne Contaminants of the American Conference of Governmental Industrial

Hygienists (ACGIH) has proposed a time-weighted, average limit value (for an 8-hour workday, 40-hour workweek) for all forms of asbestos of 5 fibers per milliliter longer than 5 μ in length, as determined by the membrane filter method at 430-times magnification phase-contrast illumination.[12] This Threshold Limit Value (TLV) has been developed as the air concentration of asbestos fibers which (1) should afford protection against asbestosis, and (2) reduce to an acceptably low risk the development of neoplasms. This TLV does not assure complete elimination of the carcinogenic risk because of incomplete understanding of dose-effect relationships. Moreover, even though different forms of asbestos appear to have different toxic effects, a single TLV was established for all forms because of incomplete information about these differences.[13]

In June 1972, a similarly documented but lower Time-Weighted Average (TWA) of two such fibers—proposed earlier in the year by the National Institute for Occupational Safety and Health, Public Health Service, US Department of Health, Education, and Welfare—was adopted for all forms of asbestos, effective July 1, 1976, by the Occupational Safety and Health Administration (OSHA), US Department of Labor. Until that effective date, the 5-fiber TWA discussed above applies as the US standard for all forms of asbestos.[14]

It should be noted that all these standards are based on the identification and quantification of all forms and types of asbestos fiber by phase-contrast (optical) microscopy. Although evidence about their toxic effects is still not well understood, certain chrysotile, crocidolite, and other asbestos fibers are too short and/or fine to be detected except by electron microscopy. Essentially the same can be said of chrysotile fibrils—ultramicroscopic morphological units of a chrysotile fiber mentioned in the section on Environmental Exposures and illustrated in the Figure.

Talc. — For 1972, the ACGIH has a TLV for each form of talc:[12]

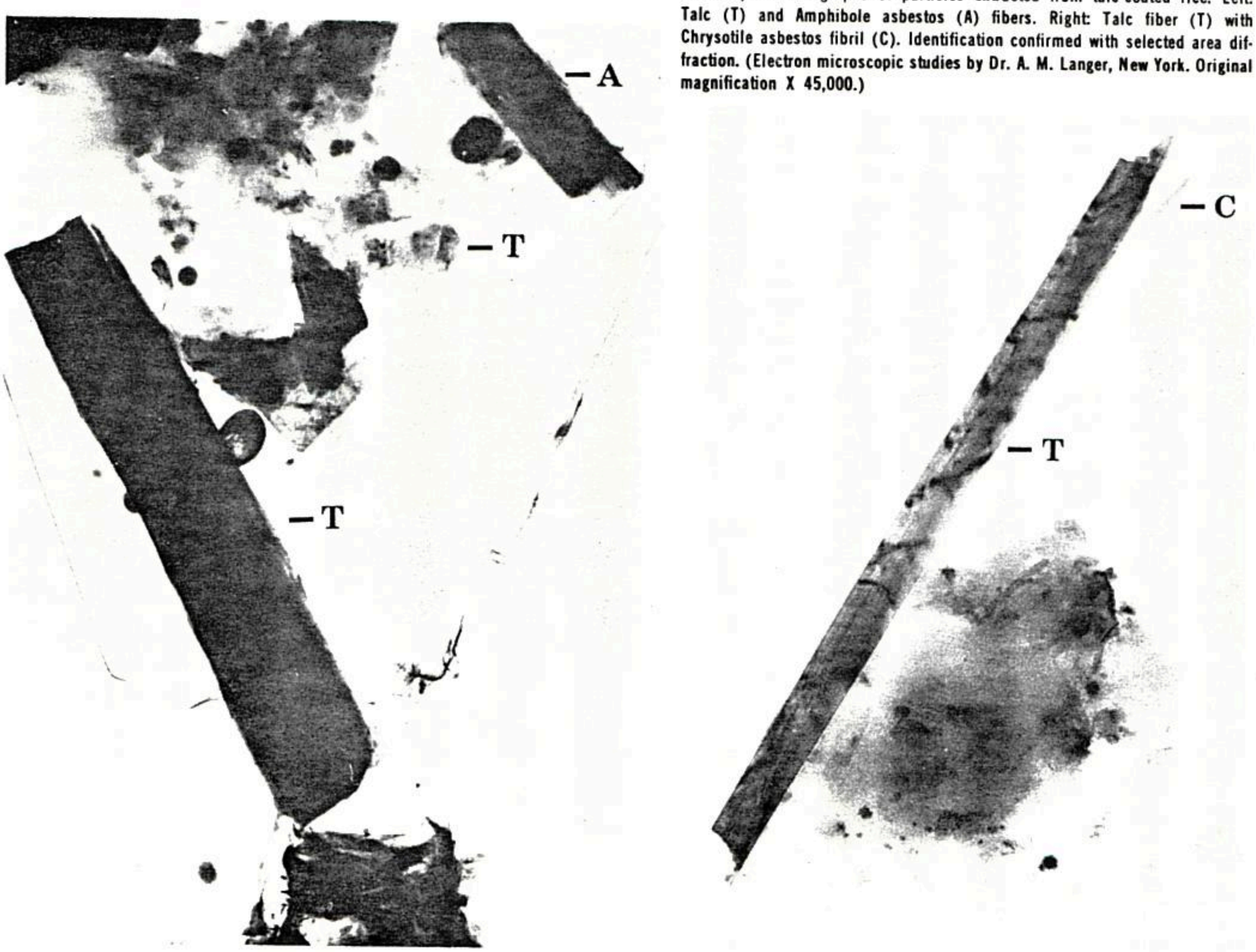
(a) *Nonasbestiform Talc:* 20 million particles per cubic foot of air (mppcf), based on the Light-field dust count.
(b) *Fibrous Talc:* The same TLV of 5 fibers discussed above.

The Documentation for these TLV's takes into account the different biological effects of the two forms of talc and of the need to determine their type and purity.[13]

The revised Table G-3—*Mineral Dusts* in the same OSHA standards cited[15] lists only one hygienic work standard of 20 mppcf for talc. This is an error which should be rectified. Otherwise, the 20 mppcf applies as the US Federal Standard for both platy and fibrous talc.

Environmental Exposures to Talc

Talc is ecologically virtually ubiquitous through its many uses in modern living. Only very recently has



Electronphotomicrographs of particles extracted from talc-coated rice. Left: Talc (T) and Amphibole asbestos (A) fibers. Right: Talc fiber (T) with Chrysotile asbestos fibril (C). Identification confirmed with selected area diffraction. (Electron microscopic studies by Dr. A. M. Langer, New York. Original magnification X 45,000.)

there been some indication of its widespread environmental inhalation and other exposures to humans. As reported in 1972, Langer et al[16] set out through electron microscopy to identify asbestos materials in the lungs of 28 consecutive autopsy cases of New York City residents. Asbestos bodies were found in only three cases, whereas chrysotile fibers were present in 24. Moreover, chrysotile fibrils were found in all 28 cases. In addition, clay and/or talc particles were identified in the lungs of 18 of these 28 decedents, all of whom had been long-time residents of that city. None had been asbestos workers nor, from our review of the published data, talc workers. Recently, Henderson et al[17] drew attention to the close association of talc and asbestos minerals when, searching for asbestos through special electron microscopic techniques, they unexpectedly identified talc particles deeply imbedded within the tissue of primary ovarian, endometrial and cervical carcinomas. Table 3 summarizes these data and also shows that no talc particles were found in the one secondary ovarian carcinoma thus studied. Additionally, the same investigators found talc particles also in "normal" ovarian tissues removed from patients with breast cancer. They made no comment, however, as to how the talc particles reached the ovaries and other reproductive tissues in which the talc was found; nor did they comment as to whether the presence of talc was adventitious or causative.

Table 3. — Talc Particles Found in Selected "Normal" and Cancerous Female Reproductive Tissues*

Specimen	Number		Talc Found† Number		Talc Found† Percent
Primary Tumor	35		23		66
Ovary		13		10	77
Cervix		21		12	57
Endometrium‡		1		1	100
Secondary Tumor	1		0		0
Ovary‡		1		0	0
"Normal" Ovary From Patient With Breast Cancer	12		5		42

* Source: Henderson et al.[17]
† Particle size range: 1000 Å = 5 um
‡ Same patient

A different study reported in mid-1971 by the Environmental Sciences Laboratory, Mt. Sinai School of Medicine, The City University of New York, revealed that significant amounts of asbestos were present in two brands of commercial, household-use fibrous talc dusting ("talcum") powder. As a result, the US Food and Drug Administration announced that if such results were to be corroborated by an independent expert panel, it would ask the manufacturers to recall such "talcum" powders. It is of interest that independent geologists informed the FDA that talc and asbestos can appear in the same mines, and that contamination could be caused at that source.[18, 19]

Uses of Talc

General. — Talc is found in cosmetics; spray and dusting powder, including "talcum"; chalks and crayons; ceramics; electric and heating insulating materials; roofing materials; insecticides; foundry facings; textiles; white shoe polishes and glove cleaners. Talc is also used as pigment in paints, varnishes, and rubber; filler for asphalt, paper, rubber, plastic, and soap; dusting powder in rubber manufacturing, and products such as inflatable toy ballons, prophylactic condoms, and contraceptive diaphragms.[1, 10]

In Foods and Drugs. — Talc also enters into food processing and pharmaceuticals. It is used as an excipient and filler for pills and tablets; for dusting tablet molds; in clarifying liquids by

Table 4. — Talc Used in the United States* and Sold or Used in California 1959-1963 Average†

Use	Percent United States	Percent California
Total	100	100
Ceramics	38	60
Paints	21	21
Rubber	5	3
Insecticides	4	2
Paper	4	2
Roofing	7	—
Toilet Preparations	2	2
Textiles	2	‡
Asphalt Filler	2	‡
Foundry Facings	‡	—
Refractories	‡	‡
Rice Coating	‡	2
Crayons	‡	—
Other Uses	15	8

* 1963 US consumption: 763 x 10^3 short tons.
† Source: Wells.[1]
‡ Less than 1 percent

Table 5. — Age-Standardized Death Rates for Malignant Neoplasms of the Stomach, by Sex, Japan and Various Ethnic Groups in California

Area and Ethnic Group	Rate Male	Rate Female	Rate Male/Female
Japan*	68.6	35.5	1.9
California†			
Issei‡	29.9	13.0	2.3
Nisei§	11.7	11.3	1.0
Black	14.6	4.9	3.0
White	8.0	4.0	2.0

* 1964-1965. Source: Segi et al.[22]
† 1957-1964 for Issei and Nisei; 1959-1961 for Black and White. Source: Dunn and Buell.[26]
‡ Foreign born Japanese.
§ US-born Japanese.

filtration; in salami dusting; candy molding; in peanut polishing; and in the coating of polished rice.[1 10] Table 4 presents quantitative data on many of these uses in the United States and California.

Talc-Coated Polished Rice

As stated above, talcs are used in a multitude of ways which can lead to widespread inhalation, ingestion, and other exposures. One such major use involving ingestion is that of talc-coating of polished (white) rice.

In the United States, and especially in California,[20] a significant portion of the polished rice is coated with glucose and talc. This process, which imparts to white rice a pearly, esthetically more attractive appearance and may also prolong its shelf-life, has to our knowledge, never been traditionally used in the Orient. Currently in California food stores it is common to see sacks of rice displaying the mandatory warning label that the rice contains added talc and glucose and that it should be washed before cooking. Consequently, we set out to determine whether the talc used in such coated rice contained asbestos and, if so, whether a related asbestos-ingestion exposure existed.

New Findings. — In this regard, early in 1971, using phase-contrast microscopy we could not identify any asbestos in the residue obtained from washings of uncooked California-processed talc-coated rice. Later, however, electron microscopic studies using selected area diffraction were done to analyze similar samples of talc-coated rice bought at nearby stores in small quantities (eg, 85 gm for 4 cents) scooped out of large rice sacks and handed over the the clerk in a plain, brown paper bag. Amphibole asbestos fibers and Chrysotile fibrils were identified in the mineral residue, as shown in the Figure. Similar work done by another program of the California State Department of Public Health in Berkeley also identified asbestos in samples of talc-coated rice sold locally. At essentially the same time the Environmental Science Laboratory, Mt. Sinai School of Medicine, the City University of New York, extracted the minerals from several samples of talc-coated rice marketed in the West Coast of the United States. Such extracts were prepared from both uncooked and washed, cooked rice samples. Similar analyses revealed that all samples were contaminated with much Amphibole asbestos (A. M. Langer, personal communications, Feb, Mar, Apr 1972). Similar work done at the School of Public Health, University of California, Berkeley, revealed essentially identical results, even after multiple washings of the rice (J. C. Murchio, personal communications, Feb, Jul 1972).

Discussion of New Findings

Regarding the asbestos contamination of California-processed talc-coated rice, our findings and those of others cited above appear to be important for a number of reasons. Firstly, talcs have no nutritional value.[20 21] Thus, agricultural researchers have tried unsuccessfully to convince the rice-processing industry to substitute talc for other substances with some nutritional value—even though, to our knowledge, these researchers did not know that talcs could be contaminated with asbestos. Secondly, the "Delaney Amendment" to the US Food Additives Act essentially prohibits the use of any food additive substance known to be carcinogenic to man or any animal. Thirdly, the Hawaiian, Italian, Latin American, Okinawan, and Spanish peoples currently prefer the smooth and shiny talc-coated type of white rice, such as the one processed in California. In fact, the Associated Commonwealth of Puerto Rico buys much of this type of rice, and requires that all rice sold there be both enriched and talc-coated.[20] Some of the nations cited, as well as others in the Orient where white rice has been a staple for centuries, continue to experience widely different age-standardized gastric cancer rates, and none higher than Japan. Moreover, in some European and other nations where rice is not a staple, the pertinent gastric cancer rates are almost as high as in Japan.[22 23] World-wide, such high gastric cancer experience can, therefore, be ascribed specifically neither to just a habitually large intake of uncoated white rice nor to a habitually large intake of asbestos-contaminated talc-coated rice, as one report in *Science* did recently.[24] Thus far, the one common denominator in gastric cancer throughout the world appears to be a gross nutritional imbalance with an intake high in carbohydrate, low in fat and certain vitamins, as well as, in some cases, high in spicy and/or salty additives. For example, the Japanese ingest large amounts of white rice and salty sauces;[25] they also have, as a nation, the highest age-standardized gastric cancer mortality and morbidity rates.[22 23]

Lastly, for a variety of environmental factors which are not clear but which point to dietary changes, the foreign and US-born Japanese in California are at a much reduced risk from gastric cancer than the Japanese in Japan.[26] This change is quite evident from the data in Table 5. In the last few years these Californians of Japanese extraction have begun to show a new and marked preference for short-grain, talc-coated rice.[20] Apparently, except for the talc-coating, this is the same rice traditionally and habitually eaten in Japan, since most of the California-produced rice is of the japonica variety of Oryza sativa.[20 21] Given the possibility that the ingestion of enough asbestos-contaminated talc were to be carcinogenic, the question arises, therefore, whether the Japanese-Americans might not be adding to their risk of gastric and other gastrointestinal cancers[26] from their new and increasing ingestion of enough asbestos-contaminated talc-coated rice, thereby counteracting the gastric cancer-reducing factors in their new environment? Similarly, might other cited nations and peoples who now also prefer talc-coated rice be at a similarly greater risk? If this were so, and considering the long lapse-time for the carcinogenic effects of asbestos to become manifest, it would take years, maybe decades, to find conclusive answers. In any case, talc has no known nutritional value. As such, its use as a food and drug additive is questionable, at least, and unwarranted if these talcs are contaminated with asbestos.

General Conclusions and Summary

Talcs can be contaminated with asbestos minerals. Both talc and asbestos produce various fibrosing conditions. Asbestos as well as asbestos-contaminated talc are known to be occupationally associated with excess mortality from various cancers. Talc enters into our lives through everyday-use items. Ingestion, inhalation, skin, vaginal, and other routes of talc exposure and absorption might, therefore, be associated with increased environmental and consumer health risks. Environmentally produced deposition and retention of talc particles in human lungs appear to be widespread. Also, talc particles have been found in some normal ovaries, as in the core of primary cancers of the ovary, endometrium, and cervix of nonoccupationally talc- or asbestos-exposed women in Britain. Nevertheless, the presence of talc in these tissues cannot presently be said to be more than adventitious, and a finding whose significance must await corroboration by well-controlled studies, preferably from diverse geographical areas. Moreover, many talc dusting ("talcum") powders and California-processed talc-coated rices recently tested were found to contain significant amounts of asbestos. Such findings raise questions of possible world-wide increased health risks to humans, arising from occupational and environmental exposures to those every-day use cosmetics, foods, drugs, and other products which contain talcs significantly contaminated with asbestos.

It is not the intent here to imply that all forms of talc pose an occupational or environmental carcinogenic risk, although there are obvious instances in which certain talcs can be a source of asbestos exposure. The data presented here indicate that whenever talc exposures are expected to occur, adequate analyses be done beforehand to determine that mineral's type and purity, as well as the related need for proper occupational and environmental controls. This approach is warranted because, in our experience, many exposed employees and consumers at large consider working with or using talc-containing materials essentially safe, which has not been the universal occupational experience. Although there is no scientific evidence of any carcinogenicity of talc per se, we would be remiss if we did not suggest a need for feasible, properly controlled experimental animal exposure studies to ascertain any possible carcinogenicity of pure talc.

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